Simulating Civilians for Military Training: A Canadian Perspective

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ABSTRACT

The contemporary operations environment involves constant contact between military units and local populations. It is therefore necessary that the human terrain be properly represented in the synthetic environments used for military training and experimentation. This paper presents the results of two knowledge elicitation activities. The first was conducted with Canadian Army training experts to assess which features would be desirable in a tool to simulate civilian "patterns of life". The second activity was conducted with military personnel who were deployed in different operations around the globe, in order to document their observations of civilian activity in different areas of the world.

1.0   INTRODUCTION

Modelling the "human terrain" has drawn the interest of a growing community of defence and security researchers in recent years. The topic has imprecise boundaries however as in different contexts it can either refer to research in anthropology, sociology, psychology, geography, computer science or a combination of these disciplines. One of the most visible efforts in the military domain has been the Human Terrain System project initiated by the U.S. Army Training and Doctrine Command (TRADOC) [1]. Significant effort has also been invested in modelling crowds for security purposes [2]. In the military simulation community the topic is also being referred to by various other appellations such as "brown noise", "clutter", "pattern of life" or "cultural modelling" for example. Described in such wide terms, the problem of modelling civilians includes many disparate dimensions that appear particularly difficult, if not impossible, to integrate in a single model.

In recent years many software tools have been introduced to help military trainers and decision makers simulate civilian populations and crowds in the context of military operations [2-5]. Many of these tools can be integrated with existing simulations and wargames by using standard interoperability protocols such as DIS or HLA. Typically, civilians are represented by these programs as individual agents that behave according to sets of behaviour rules, often dependent on their perception of the environment. These tools provide user interfaces that typically offer a certain degree of control over the simulated civilian actors. In parallel to the development of civilian simulators, researchers have created several cognitive frameworks to model civilian reactions and decision making [5-8]. The idea is to provide a common structure to model entire classes of human behaviours.

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One common frustration in the field is the scarcity of data available to create and validate civilian behaviour models. Often, the cognitive frameworks designed for behaviour modelling remain to be filled with the metrics appropriate for each context. On the users' side, it is often perceived that these metrics, and the data that backs them, should be provided by the researchers. On their side, the researchers often argue that the users know best about their own particular context of operation, and that they are in a better position to fill in the blanks, using their own intelligence and experience.

Because of the risks inherent to zones of conflict, the collection of live data on civilian behaviour is practically impossible. The lack of direct and repeated observations limits the extent to which validation can be conducted. In that context, letting the algorithms decide when and where certain collective phenomena should occur, such as spontaneous gatherings, or the onset of violent behaviour, would be arbitrary.

The research presented here does not focus on any specific tool or cognitive model. The work presents the requirements for a simulation of civilians as determined from the current needs of the Canadian Land Force, in particular within the domain of wargame-based training and experimentation.

The most obvious gap that appeared initially in the Canadian Land Force synthetic environments was the scarcity of civilian populations, and the inaptitude of the wargames to represent proper civilian demographics. It has been pointed out by Wong [9] that because civilians in wargames are often represented in artificially low numbers – sometimes underestimated by orders of magnitude – distortions will necessarily appear in the tactical and strategic outcomes of such exercises. While estimating potential civilian casualties is not the least of these gaps, a few others can be pointed out, such as:

- Identifying the difficulties military forces may face in densely populated areas, including both operational factors such as obstructions and interactional factors such as angry crowds.

- Obtaining realistic force structure requirements for operating in these environments, depending on the number and stance of the civilians present.

- Characterizing how real-life interactions between military forces and civilians can impact the realization of mission objectives.

- Recognizing how certain patterns in civilian activity can reveal information about the environment that might not be visible otherwise, the presence of hidden insurgents for example.

It is reasonable to expect that civilian traffic will affect the realism and outcome of convoy operations (Figure 1). Also, without any civilians, target aquisition and identification can become unrealistically straightforward. In an environment empty of normal human activity the level of uncertainty is in fact artificially reduced (see Figure 2). Seen from higher levels of decision, these phenomena will have operational and strategic consequences.

This paper presents the results of two knowledge elicitation activities. The first was conducted with Canadian Army training experts to assess which features would be desirable in a tool to simulate civilian "patterns of life". The second activity was conducted with military personnel who were deployed in different operations around the globe, in order to document their observations of civilian activity in different areas of the world. While it is difficult to derive algorithmic models of human behaviour from such observations, they can however reveal recurring patterns in civilian activity across the world.

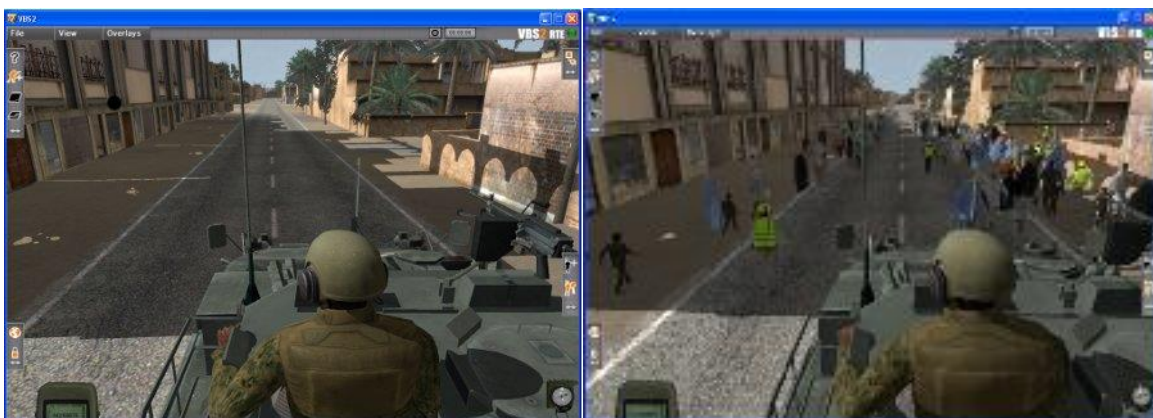**Figure 1: Military convoy in a densely populated area.**

**Figure 2: Two views of a narrow street in a virtual simulation (VBS2). The view of the busy
street (right) shows a richer and more environment than the empty one (left),
with an increased level of uncertainty.**

2.0   KNOWLEDGE ELICITATION ACTIVITY I: REQUIREMENTS FOR A CIVILIAN SIMULATOR

In early 2009 a series of interviews were carried out with Canadian Land Forces staff and contractors involved in training exercises. The objective was to assess which features would be desirable in a civilian simulation tool. The participants included developers, training supervisors and other subject matter experts on approaches to training both with the Joint Conflict and Tactical Simulation (JCATS) and with Virtual Battlespace 2 (VBS2). JCATS is a constructive simulation with a 2D map interface while VBS2 is a serious game (also called virtual simulation) that reminds of first person shooter (FPS) games (see Figure 2). These wargames are used for the majority of simulation-based exercises organized by the Canadian Army.

The interviews were intended as an exploratory exercise and were not restrained to a predetermined set of questions. The comments obtained in each interview were subsequently re-organized along the themes of interoperability, user interface and modelling. This structure is reflected in the subsections below.

2.1 Requirements Related to Behaviours and Emergent Phenomena

For military training a phenomenological approach to behaviour representation is a viable alternative to a more comprehensive cognitive approach. A main objective of training by constructive and virtual simulation is to create situations where learners have to make decisions based on a combination of competing factors. These factors are determined by the training authority. For that purpose it is thus preferable to program simple descriptive behaviours that give rise to expected emergent phenomena (e.g. citizens going to a same market will naturally create a congregation; many cars heading downtown will create a traffic jam on a large scale). Table 1 gives a summary of the civilian phenomena, including some individual behaviours, that came up during the requirements gathering activity.

It is convenient to distinguish between behaviours that are either "ambient" or "triggered" behaviours. Ambient behaviours include examples from Table 1 such as "Stand around", "Carrying large items" or "Haggling or Negotiating". Some events in the simulation however should trigger responses different than those default ambient behaviours. In zones of conflict, an important category of events that can trigger sudden responses are weapons effects such as explosions, weapons discharge by a shooter or bullet impacts.

It was also mentioned however that there is still a need to trigger certain ambient phenomena depending on the time of day, to reproduce the changing dynamics of a town as the day advances. Such a capability becomes important in the context of exercises that last continuously over several days, in order to convey an impression of permanence of the population, and to ease the task of the operator who would otherwise have to perform a large number of timed, mundane tasks.

On top of the requirements enumerated here, the validation of the basic attitudes of pedestrians remains another challenge. When interrogated, training experts have emphasized that a process needs to be in place to show behaviours to intelligence staff and armed forces personnel coming back from deployment, in order to get feedback on whether the representations that are used are appropriate or not. This is why our research has recently focused on documenting civilian activity in different areas of the world through interviews with military personnel who were deployed in different operations around the globe. While this knowledge elicitation process cannot directly provide formal behaviour models , it can however reveal recurring patterns in civilian activity across the world. This exercise can be seen as cataloguing the geotypical and geospecific patterns of the human terrain. This analogy is particularly interesting for the training of military decision makers. Klein [10] has indeed argued in his Recognition-Primed Decision (RPD) model that pattern recognition is essential to making decisions under pressure, and that in training one solution is to teach novices to recognize the same patterns that experts use in making their decisions.

Table 1: Types of behaviours suggested by Canadian military training experts in the requirements collection activity. A suggested level of detail has been added for the applicability of each, covering broad (B), medium (M) and fine (F) scales. (A) is for "All scales".

Behaviour Type	Description	Scale
Stand Around	Just hanging around.Minor motion relative to other agents.	A
Walking Around	Walking around a specific neighbourhood. Perhaps driven by a maximum distance from origin.	A
Small Groups Talking	Small congregations with dialogue, then breaking up and reforming.	A
Flee randomly	Fleeing from local cause for alarm.	A
Crowding	Any group gathering, density function driven, no specific cause.	B
Watching / Curiosity	Watching some target with some attention. Curiosity may spread to nearby agents.	M,F
Protesting	Similar to watching but posture more assertive to aggressive and ambient noise loud.	M,F
Subtle Move Towards	Trying to get closer.	M,F
Subtle Move Away	Trying to put distance between.	M,F
Carrying Large Items	Moving carefully with large items, children in arms. Noticeably different movement patterns.	M,F
Directing Behaviour	Traffic cops. Mothers at children. Religious figures at everyone. Directedfigures may modify behaviour.	M,F
Flee with intent	Fleeing towards a specific point, either a known safe-haven or a goal	M,F
Inciting	Trying to change behaviour status of surrounding agents (e.g. calm them down, make them angry).	M,F
Screening	Trying to keep between *us* and *it*. It might be a building, an individual or a group	M,F
Walking along road edge	Pedestrian behaviour without inappropriate interactions with cars.	M,F
Sit / Stand / Kneel / Lie	Modification to behaviour. Possibly triggered by events.	F
Cowering	Physically submissive, quiet.	F
Helping / Healing	Medic behaviour.	F
Haggling or Negotiating	Talking to merchants for a set amount of time, then exchanging goods or cash for goods.	F

2.2 Interoperability Requirements

In the Canadian context, a civilian simulator must interoperate with tools such as JCATS and VBS2 as well as various middleware used for maintenance and data logging. Consequently, it was recognized by the participants that for most applications, a dedicated piece of software would be required for simulating civilians, rather than a set of scripts specific to an already existing simulation. As a result, some requirements are specific to the good interoperability of the software with the simulations on a network.

Terrain compatibility is a recurring issue in interoperability. Because a civilian activity simulation would be an add-on rather than a full-fledged wargame it should not introduce an additional terrain format. Such a simulation should rather import standard GIS data or even more specific formats such as VBS2 terrain files or OpenFlight models.

Another capability that was repeatedly mentioned by subject matter experts (SMEs) is the ability for a human controller to "jump" into an automated civilian and impersonate it using VBS2 for example. This comes from the need to represent enemies hiding in civilian groups so that they blend into the background population.

2.3 User Interface Requirements

It was made clear by the participants who were interviewed that a civilian simulation should be interactive, with a human operator having the possibility to control groups or individuals directly if needed. If a human-in-the-loop approach is to be used it means the human controller will make some decisions in place of the simulated civilians (e.g. trigger small gatherings, direct marches). It is thus important for the user interface to allow a good level of immersion in the environment, and to offer effective tools to quickly add/remove civilians, individually or en masse, and modify some individual or collective attributes. Also, in typical training events and even in experimentation, changes are often made on the fly to the scenarios to accommodate last minute adjustments. Therefore it is essential that a civilian simulation tool be able to adapt the civilian landscape to these changes.

In line with other military simulations, the interface map has to present a grid system with readable coordinates (e.g. a grid overlay or a pointer-coordinate system). The proper reporting of the time of day and weather are also essential.

If the civilian simulator is to make use of standard geographic data files for input it is essential that it has the ability to encode the environment according to the civilian activity that is expected to occur in those areas. The idea would be to encode the existing terrain features, not create new ones. For example a polygon would label a zone on the map as a market place, so that civilian agents reaching that area can adapt their behaviours according to that context.

To favour agility, it is also important that means exist in the simulator to quickly create populations, groups and individuals on the map. Once these civilians are created, it becomes important to be able to change their behaviour rapidly, and selectively, if needed. One approach that was favoured is the use of brushes to "paint" moods and behaviours on already existing agents. It was preferred by the experts interviewed that these brushes only modify the mood (e.g. increasing fear, or aggressiveness) temporarily with behaviours, slowly returning to normal. Although permanent modifications would be desirable as well, it was perceived that in the rapid pace of an ongoing exercise, it might be better not to have to think about reverting these civilians back to their normal state manually.

A behaviour building interface was deemed essential by most interviewees. However, few had a clear idea of what form that interface should take. This could be due to the fact that behaviour specification is not undertaken by experts at the level of the ones we interviewed. Also, it is possible that the activity of specifying behaviours is more difficult to visualize because it does not take place in space, like creating or modifying civilian entities.

3.0 KNOWLEDGE ELICITATION ACTIVITY II: CIVILIAN BEHAVIOURS ACROSS THE WORLD

Modelling civilian activity is difficult in part because of the lack of source data to help build the models. This is paradoxal since each one of us participates in one way or another to civilian activity on a daily basis by going to work or attending public events for example. Moreover, experience of civilian activity in foreign countries is widespread, especially in the military. A knowledge elicitation process was thus initiated, involving tens of hours of interviews with Canadian military personnel who have been deployed in theaters across Africa, Asia, Europe and the Americas (see Figure 3). That process has provided many previously unknown parameters, allowing to characterize some basic features of the civilian background activity in different regions of the world and to distinguish likely activity patterns from less likely ones.

Figure 2: Areas of the world covered in the interview process.

In what follows we provide a preliminary analysis of those interviews and the input they provide for modelling civilian activity. We grouped the information in sections related to individual and group behaviours, traffic patterns and the presence of animals. We felt that this structure was the most natural for the reader interested in building models of civilian activity. The interviews have provided important insights on other considerations such as the characteristics of the urban landscape in different cities across the world as well as accounts of multiple real-life vignettes which provide insight on the conduct of operations in urban environments.

3.1   Individual Behaviours

Interviews with subjectmatter experts have shed light on how individual behaviours vary across the spectrum of conflict. Although there existmany variations on this concept – each military organization having its own construct it seems – they all refer to the same idea of a one-dimensional intensity scale ranging from humanitarian aid to all-out war. As expected, we found that civilian activity is almost exclusively relevant to the first half of the spectrum, up to the level at which the "three-block war" concept applies [11]. In higher intensity conflicts civilian populationswill either have been evacuated, have left the affected areas themselves or be in hiding (recent examples are Operation Medusa in Afghanistan (2006) or the second offensive on Fallujah in Iraq (2004)).

An important feature is the adaptation of civilians to the intensity of conflict. As a conflict suddenly intensifies the activity in a town might shut down completely at first, but only temporarily. In Bosnia and Herzegovina citizens of besieged urban areas were observed to go about their daily business under sporadic mortar shelling and sniper fire. Another form of adaptability is also observed as civilians get used to the sight of military units in their environment and become indifferent to them. One officer familiar with the theatres of Haiti and Afghanistan confirmed this tendency in both countries. Generic indifference has also been reported for all the theatres we investigated. The adaptation time depends on the number and frequency of sightings. We do not have a quantitative evaluation yet but in densely populated environments it has been reported to be of a few days and less than a week. As such it seems plausible that this feature is universal.

While indifference towards military presence is a dominant feature, it is not to say that hostility is not observed. Hostility was encountered by most of our interview participants, although it was often difficult for them to describe how it was manifested. We found that, while being obvious to the observer, hostility is often conveyed through subtle, non-verbal cues: stern looks or avoidance of eye contact, absence of response to friendly waving. Explicitly hostile gestures were seen only in uncommon cases where a hostile crowd would form (see next section). We believe it is in the most visually realistic wargames that the representation of such background hostilitywill be the hardest.While the icons in a constructive simulation can be given different shapes or colours to signify changing emotions, believable 3D representations of facial expressions is still in its infancy and is an active area of research in computer graphics, animation, and cognitive science. Moreover, the screen resolution at which virtual simulations are played would probably not allow perception of these subtle expressions.

Another exception to the indifference rule are the gatherings of children around vehicles or groups of soldiers on foot. While these are often depicted in the media, our results indicate that they are not so common and seem to happen mostly in the countryside. The recent policy of the Canadian Forces has also been to distribute presents to responsible adults rather than directly to children, which might have reduced the occurence of such swarming. Small groups of curious bystanders will also gather whenever a soldier engages in conversation with a civilian in a public place.

Attacks with improvised explosive devices (IED) have been common during the current mission in Afghanistan and some of the soldierswe interviewed had witnessed such events. We found out that the hypothesis we had made of an initial outflow of people fleeing the proximity of the deflagration, followed by a subsequent inflow of curious people from nearby areas was correct. The return of people to the scene seems to happen in the 5 to 15 minutes following the event and the density of people gathering will depend on how densely populated the area of interest is. The desire of incomers to see what happened willmotivate some of themto climb up the walls of compounds and the roofs of buildings, which can add to the risk perceived by the soldier. It has also been reported to us that as word of mouth spreads people from as far as a kilometer away

could be observed converging to the scene of an explosion or accident. This phenomenon plays an essential role in determining how fast a security cordon must be established following an IED detonation.

From what we have gathered the description of individual behaviours in the above paragraphs seems valid across the cultures we surveyed. One aspect that varies significantly however is the visual appearance and the composition of the population that is visible on the streets. While in most countries the proportion of men and women is equal, in some cases the proportion of women is lower. In a typical Afghan urban area it is estimated that women comprise only about 20% of the pedestrian crowd; the rest is made of men and boys. In the countryside the propoprtion of women seen outside is higher.

3.2   Behaviours Specific to Crowds

Not only do demographics vary between regions, but different subgroups of a population will also have different ambient and responsive behaviours. Since the end of the 19th century there has been a growing interest in figuring out how crowds behave [12]. As military organizations have shifted their focus to operations other than war in the last few years, there has been a sharp increase in crowd research from the points of view of security and defense.

Apart from appearing critical, the problem of modelling crowd behaviour is also notoriously difficult for two reasons. First it involves feedback mechanisms that are poorly understood. Second, interactional dynamics withmany agents in a crowd mean that computational demands will be extreme.

One should distinguish between the behaviours specific to an organized crowd and the collective effects caused by the addition of independent agent behaviours. In some cases pedestrians can independently converge in the same area. One example is the gathering phenomenon following an explosion as described in the last section. However there is arguably more to an organized crowd than the sum of its individuals and characterizing that distinction is where the challenge lies. Nevertheless, it seems from the data we gathered that the formation of organized crowds occurs relatively rarely.

Most of the crowd gatherings that have been described to us were triggered following road accidents, often when a pedestrian was hit.While some incidents reported to us involved collisions between military and civilian vehicles, others involved only civilian vehicles that were encountered by military convoys after the fact. We were told that in tense contexts the presence of a foreign military unit on the site of an accident, be it involved in the accident or only helping, might possibly lead to a hostile response from the gathering crowd, although rarely violent. Hostililty could be a consequence of a misinterpretation of the situation. Onlookers arriving where an accident occured might jump to conclusions and accuse the military of being responsible. Through word-of-mouth a rapid flow of information follows. This contagion effect is characteristic of crowd dynamics.

Only two cases of outwardly violent gatherings were reported to us, one in Kabul and the other in Kinshasa. In one case an official, non-armoured vehicle was attacked by a handful of angry teenagers armed with sticks. In the other a few hundred angry adults converged on a barricaded military compound and started throwing rocks inside. For the officers involved, each incident was a once-in-acareer occurrence and both required the use of firearms in a non-lethal way as means of dissuasion.

These accounts indicate the importance of doctrine addressing crowd violence. They do not constitute sufficient data however to attempt building a crowd violence model. Nevertheless it indicates the need in a civilian activity model to be able to trigger a violent state for agents in circumstances that should be determined by the human who is designing the training scenario.

3.3   Traffic Patterns

Our interviews indicated a uniformity in the traffic patterns observed in developing countries. These patterns stand in contrast with traffic as it is observed in industrialized countries. In regions where minimal infrastructures have to handle larger numbers of vehicles than they have been built for, there is a tendency for drivers not to stick to the rules of traffic. Lane divisions for example are disregarded and rights of way seldomrespected. On busy streets in densely populated regions, especially in commercial areas, it is also common that pedestrians will overflow on each side of the road, creating a bottle neck for vehicle traffic. Jaywalking is also common, especially in blocked traffic. The consequence of these observations on modelling is that a lane-based model of traffic flow is not a valid option and that vehicle agents should use avoidance algorithms similar to pedestrians. The interaction of vehicles and pedestrians also has to be taken into account.

Another pattern observed in developing countries is the way inter-city shipping trucks are often organized in convoys. One of our interview candidates has pointed out that he had observed this phenomenon both in Haiti and Afghanistan. "Tens and tens" of trucks will be aligned together, followed by a cohort of cars stuck behind. When they pass through towns they typically remain together and just stream in. Bottlenecks develop where, as trucks are entering cities, cars will also make their way around them, slowing themdown further. There also come stretches of time during the day where there is only car traffic because the trucks will have left earlier for the day. There will be some odd trucks by themselves here and there, but most of the time they travel in convoys.

Another common feature of traffic in developing countries is how every vehicle is usually full, either with passengers or, for trucks, with merchandise. More people per vehicle means more people on the road for the same number of vehicles. In other words, an explosion in the middle of a traffic jam might be more deadly in Kinshasa than in Montreal, where cars often carry a single person.

3.4   Presence of Animals

Most interview candidates indicated that animals had been a minor concern in their deployments. In markets most animals are tied up or kept in pens.

In the countryside it was indicated that animals can be observed at night. They are especially visible in the desert. However it was pointed out that after a short time on deployment soldiers could easily distinguish the infrared signatures of animals from those of humans.

4.0   CONCLUSION

The two knowledge elicitation activities that were conducted provide guidelines on how to implement a simulation of civilian activity for the benefit of soldier training.

There are four main recommendations related to the simulation software itself:

1) A simulation of civilian activity must be an independent module that can interoperate with other wargames through one of the standard interoperability protocols.

2) A representation of individual civilians is necessary to offer the best visual realism in virtual simulations such as VBS2. An agent-based solution is therefore the best approach.

3) There is a need for an application that allows a direct control over the civilians, in real time as the scenario unfolds.

4) In order to facilitate the creation of training scenarios and to provide good performance on the hardware available at typical training centers (non-clustered high-end PCs), the artificial intelligence models must both be simple and predictable.

The series of interviews conducted with Canadian military personnel indicate that certain patterns of civilian activity can be generalized to several countries at once (e.g. traffic patterns in developing countries) while others are specific to certain areas (e.g. street demographics in Afghanistan). Categorizing these geo-typical and geo-specific features, and determining how they influence military decision making, will be our next area of investigation.

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